power management for iot wearables systems

Abstract

Introduction

1.1 Introduction

Alzheimer's disease (AD) is a devastating neurological disorder that results in the death of brain cells, leading to memory loss, behavioral changes, and cognitive decline. It significantly impacts an individual's ability to function in daily life, affecting work, social interactions, and overall independence. Unfortunately, AD can ultimately lead to death, making it a major public health concern as the sixth leading cause of death globally.

People with Alzheimer's often experience limitations in mobility, which can confine them to their homes and increase dependency on caregivers. However, advancements in technology, particularly in the realm of the Internet of Things (IoT), offer promising solutions to enhance the quality of life for individuals with AD and support caregivers.

IoT applications allow for the monitoring of individuals with various health conditions, including Alzheimer's, in their daily lives. These applications can track vital signs, activity levels, medication adherence, and even detect emergencies, providing valuable insights to caregivers and enabling timely interventions.

Despite the benefits, one significant challenge facing IoT devices is energy consumption. Many IoT devices require continuous power sources, which can be impractical, especially for devices intended for long-term monitoring. Fortunately, there are several technologies and strategies available to mitigate energy consumption in IoT devices

This research investigates the relationship between energy efficiency, Internet of Things technologies, and Alzheimer's disease in this context. Through exploring creative fixes and exciting new approaches, we hope to shed light on the way forward for utilizing technology to improve the lives of Alzheimer's patients and their carers. By utilizing a variety of interdisciplinary techniques, we hope to lessen the effects of Alzheimer's disease while providing people with improved monitoring tools, increasing their level of independence, and improving their quality of life.

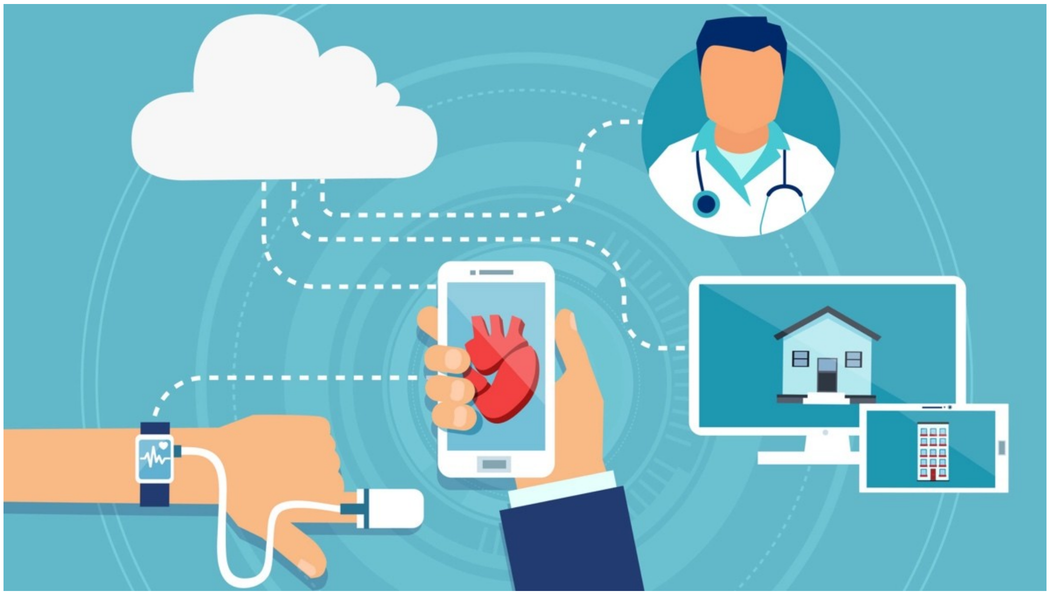


Figure 1.1 Remote real-time patient monitoring

Literature review

Saeed Mohsen and others a self-powered Internet of Things (IoT) wearable sensor device presents a hopeful resolution for the ongoing monitoring of healthcare, by utilizing solar energy collection technology to prolong its operational lifespan and lessen the reliance on traditional battery substitutions [1][21]. Laxmikant Dewangan and other focuses on reducing power consumption in a wearable IoT device. It employs low-power components like ESP8266 and ATTINY85, implements power management techniques such as sleep modes, and optimizes communication protocols for efficiency. Motion sensor data from ADXL335 is utilized for fall detection, minimizing unnecessary power usage [2]. JIAMIN LI and others focuses on reducing power consumption in wearable ECG devices. It proposes optimizations in data acquisition, processing, and transmission stages. Key findings include the effectiveness of the DMA list approach for data acquisition, the impact of sampling rates on power consumption and detection performance, and the efficiency of selected QRS detection algorithms. Additionally, transmitting processed data over Bluetooth Low Energy (BLE) is found to be more energy-efficient than transmitting raw signals. Overall, the methodology involves hardware and algorithmic optimizations to achieve energy efficiency without compromising detection accuracy [3][4]. Qunoot N. Alsahi and et al. presents a prototype healthcare monitoring system designed for real-time monitoring of heart activity. It emphasizes local data analysis to minimize the need for continuous communication, thereby reducing power consumption. Selective data transmission, optimized communication protocols, and an efficient GSM alert system further contribute to power efficiency. The system's practical application with various patient profiles validates its effectiveness in real-world scenarios [5]. Delaram Amiri and et al. focuses on reducing power consumption in wearable remote patient monitoring systems through fog computing and localized energy optimization algorithms. Key methodologies include offloading computational tasks to higher layers, incorporating contextual information to guide energy optimization, and implementing distributed control-based solutions at run-time [6]. Jose David Torres Retamosa and et al. proposes a wrist-wearable low-power device for monitoring physiological signals and daily activities to detect falls in elderly patients. It utilizes Bluetooth Low-Energy for data transmission and introduces novel algorithms for heart rate peak detection and oxygen saturation analysis. Test results demonstrate accurate monitoring capabilities with minimal deviation. The device offers a low-cost, low-power solution that integrates seamlessly into existing care workflows [7]. Fernando Luís-Ferreira and et al. focuses on reducing power consumption in devices designed to assist dementia patients by employing personalized activation and deactivation strategies based on patient profiling. By tailoring service delivery to individual needs and behaviors, the approach aims to extend battery life while ensuring timely detection and safety checks [8]. David C. Yates and et al. explore methods to reduce power consumption in wireless devices by employing data compression techniques. Through graphical analysis, optimal compression ratios are identified, typically ranging from 0.2 to 0.4, to achieve significant improvements in battery life [9]. Jaime Ortegón-Aguilar and et al. introduces a Multimodal Dynamic Power Management Strategy (DPMS) for internet-of-wearable-things (IoWT) systems, particularly in medical applications. It employs low-power machine learning algorithms to optimize energy consumption based on supercapacitor storage levels and biosignal statistics. Implemented on a PPG sensing prototype, the proposed strategy extends battery life by 3.87×, facilitating more data transmissions compared to traditional methods [10]. Md. Omer Farooq and et al. proposes a Low Power IoT-Based Implementation ECG & Health Monitoring System utilizing the MAX30100 sensor and ESP32 microcontroller. The system efficiently monitors ECG signals, heart rate, blood oxygen levels, and temperature with high reliability and accuracy. Key aspects include sensor selection for low-cost and sensitivity, microcontroller choice for low-power operation with wireless connectivity, and power-optimized design considerations. Incorporation of an LCD display and Telegram bot enables real-time monitoring while minimizing power consumption [11][12][13]. Robert Simon Sherratt , and Nilanjan Dey explores methodologies to enhance the battery life of wearable devices, crucial for their effectiveness in healthcare and other domains. It emphasizes the need to balance prolonged operation with computational and communicative demands. Key strategies include developing smarter CPU architectures, optimizing wireless connectivity, implementing efficient task scheduling algorithms, improving battery management techniques, and optimizing sensor integration and data processing. By enhancing these aspects, the study aims to enable wearable devices to operate for extended periods between charges, facilitating long-term monitoring and improved health decisions [14]. Meriam Ben Ammar and et al. utilizing energy-harvesting technologies and optimized power extraction circuits for efficient energy utilization in IoMT devices. It also includes offloading energy-intensive tasks to resource-rich fog or cloud layers, employing reinforcement learning algorithms for efficient task management, optimizing hardware implementation, and considering communication costs to ensure overall energy efficiency [15][16]. Wan Aida Nadia Wan Abdullah and et al. focuses on reducing power consumption in Wireless Body Area Network (WBAN) for healthcare monitoring through Identifying energy wastage factors during data transmission and reception, Devising strategies to minimize energy consumption, such as optimizing protocols and minimizing control packet overhead, Designing energy-efficient systems to maximize the lifespan of battery-operated sensor nodes, Integrating link- and physical-layer functionalities to optimize communication protocols and signal processing techniques, Ensuring flexibility, reliability, and cost-effectiveness in the design of the WBAN system for effective and long-term health monitoring [17]. Tim Hadwen and et al. focuse on addressing the issue of short battery life in GPS tracking devices used by caregivers for dementia patients. By inspecting the energy consumption of individual components in a GPS tracker, the study proposes a novel, energy-efficient wristband design. This design integrates LoRa communication and GPS duty cycling technologies to extend battery life and reduce the need for frequent charging [18]. Sandesh Warbhe et al. proposed reducing power consumption in the wearable healthcare monitoring system through selecting low-power components like the MSP430 microcontroller, optimizing circuit design to reduce standby power consumption, and developing efficient software algorithms to minimize processing overhead and maximize sleep mode utilization [19]. Tifenn Rault and et al. focouse on comparative study to analyze energy-efficient mechanisms applicable to various health wellbeing applications. It identifies categories of mechanisms such as power-on time reduction, communication reduction, computation reduction, and battery charging. suitable approaches for energy saving in applications like user location detection and physical activity recognition are identified, considering factors like delay and accuracy requirements [20]. Engr. Melannie B. Mendoza and colleagues proposed a wearable tracking device for aiding caregivers in monitoring Alzheimer's patients in nursing homes. Utilizing ZigBee for wireless sensing, GPS for patient location, and GSM for data transmission, the device lacks emphasis on power consumption management, crucial for long-term effectiveness [22][23]. Similarly, Bassam Al-Naami and others introduced a wearable wireless sensing smart medical device (SWMD) to manage the daily life of Alzheimer's patients. Integrating vital signs monitoring, fall detection, and GPS location tracking via a Wi-Fi microcontroller, the SWMD offers real-time alerts and data management through the Internet Cloud. However, both solutions overlook the issue of battery power consumption, which is essential for sustained device operation. [24].Also Aseel Thamer Ebrahem and colleagues introduce an IoT prototype aimed at assisting caregivers in monitoring Alzheimer's disease patients. The prototype incorporates GPS technology and alarms to locate patients and remind them of medication schedules. Through remote monitoring via the Blynk 2.0 app, caregivers can track medication adherence and daily activities. While addressing the challenges related to memory and organization in Alzheimer's patients, the prototype overlooks the topic of energy consumption, which is crucial for ensuring long-term device effectiveness [25].

Methodology

System design consists of a set of hardware and software components that contribute to building a system of Internet of Things that helps in monitoring necessary data for people with Alzheimer's disease

A set of components are connected that help in reading this data from the patient and designing a wearable device. This device is linked to the Internet of Things platform to display the data remotely. By designing this device, we will face a set of challenges that researchers face in designing wearable devices, including energy consumption, so that it can work for a longer period of time in the correct way We use a set of technologies that contribute to energy management and the operation of the device for a longer period

1.2 Problem statements

Alzheimer’s disease (AD) is a neurological disorder that results in the death of brain cells, causing memory loss, behavioral changes, and cognitive impairment. It drastically affects the individual’s work and social life, often leading to death, and is now the sixth leading cause of mortality worldwide. AD patients have limited mobility, which restricts their movement outside their homes [].

The data of these people must be monitored remotely, in addition to the possibility of providing devices that operate for a longer period

1.3 objectives

1- A wearable device based on Internet of Things technology will be designed that monitors the vital factors of people with Alzheimer’s disease, and how to design the device in a way that it works for a longer period.

2- Manage the device's energy through the use of a set of technologies that can contribute to reducing energy consumption and operating the device correctly

3- Benefits of use in the medical field and how to apply it (مو كلش افتهمتها)

Components

2.2 Hardware

- ESP32 microcontroller
- MAX30102 Pulse Oximeter Sensor.
- DHT11 humidity and temperature sensor.
- Buzzer.
- 0.96-inch OLED screen display.
- NEO-M8 GPS module.
- 3.7 V, 1100 mAh Li-ion battery.

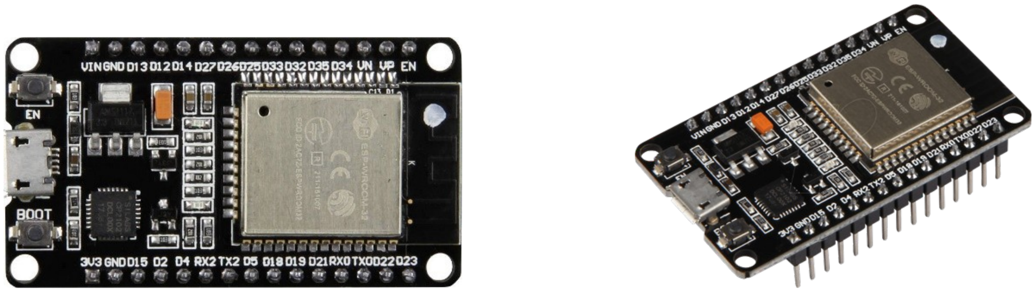
2.3 Software

- Arduino IDE. (https://www.arduino.cc).
- IoT cloud platform

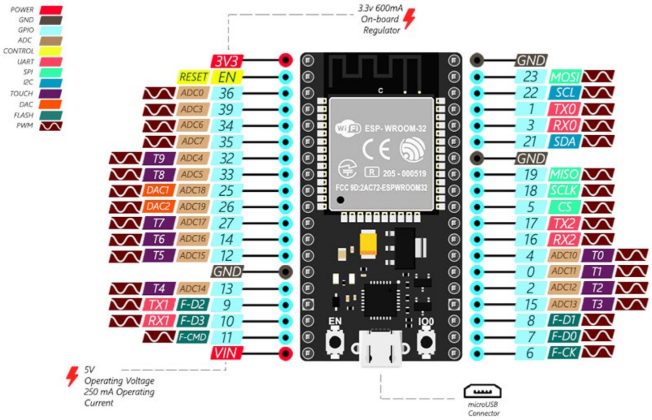
2.2 Hardware:

2.2.1 ESP32 microcontroller

ESP32 is one of the most embedded systems used in IoT projects, and it is a Soc chip from Espressif, developers of the Esp8266 chip. It comes with a single-core and dual-core and contains the Xtensa LX6 -32bit microprocessor and is integrated with wi-fi and Bluetooth. The good thing about Esp32 is that it is similar to Esp8266 with its built-in RF content, such as a power amplifier, which makes it suitable and easy to use in a lot of embedded systems and IoT projects. The other thing to know about ESp32 is that it was manufactured using technology. Ultra-low power 40nm This makes it suitable and easy to use for projects that run on low power, such as wearable devices, audio equipment, smartwatches, etc. **[1][2]**



ESP32 Microcontroller

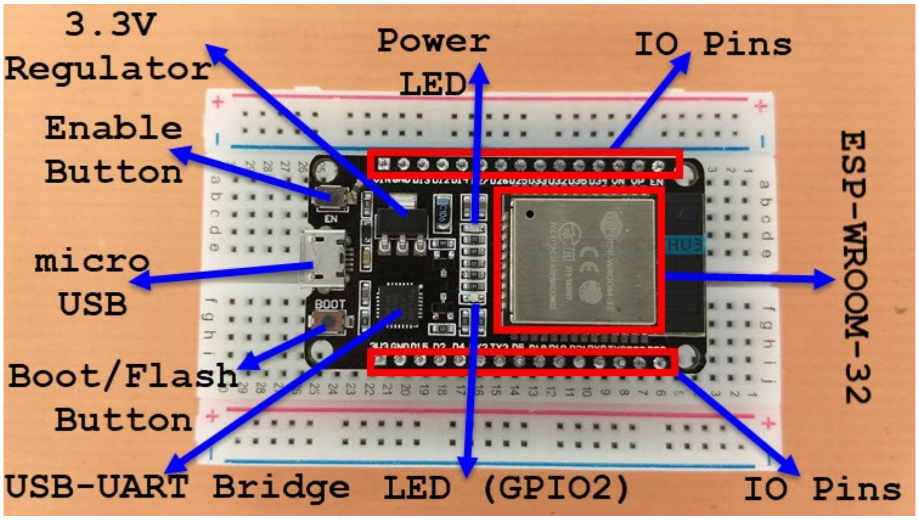


ESP32 Microcontroller pin out

Specifications of ESP32:

Esp32 has many features, so it is difficult to mention them all. Therefore, we will mention the necessary features to understand this piece and consider its suitability for our project, and since the reference for these features is its datasheet.

- Single or Dual-Core 32-bit LX6 microchip with clock frequency up to 240 rates.
- 520 kilobyte of SRAM, 448 kilobyte of store and sixteen kilobytes of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi property with hastens to one hundred fifty Mbps.
- Support for each Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to eighteen channels of 12-bit SAR ADC and a couple of channels of 8-bit DAC
- Serial property embody and UART.
- Ethernet MAC for physical computer network Communication (requires external PHY).
- one Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of crystal rectifier PWM.
- Secure Boot and Flash secret writing.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, code, and RNG.



ESP32 microcontroller board overview

2.2.2 MAX30102 Pulse Oximeter Sensor

The MAX30102 is an integrated sensor that combines the functions of measuring heart rate and pulse oximetry. This can be used in wearable healthcare devices, assistive devices, medical monitoring devices, and other similar applications. The device is equipped with two LEDs, one of which emits red light and the other infrared light. Only infrared light is required to determine the pulse rate. Oxygen levels in the blood are measured using both red and infrared light. The MAX30102 main function is to read the absorption levels for both light sources and store them in a buffer that can be read via I2C. This module is used in the proposed prototype in accordance with the useful functions that must be incorporated into our proposed project. Figure 12 depicts the shape of the sensor.

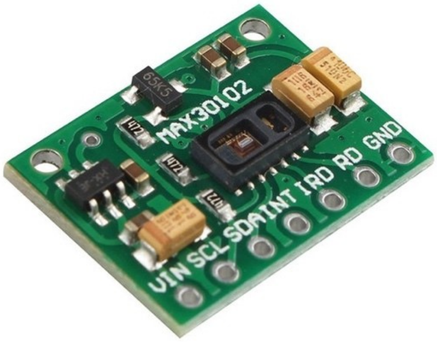


Fig 3.6 Pulse Oximeter SpO2 - Heart-Rate Sensor (MAX30102).

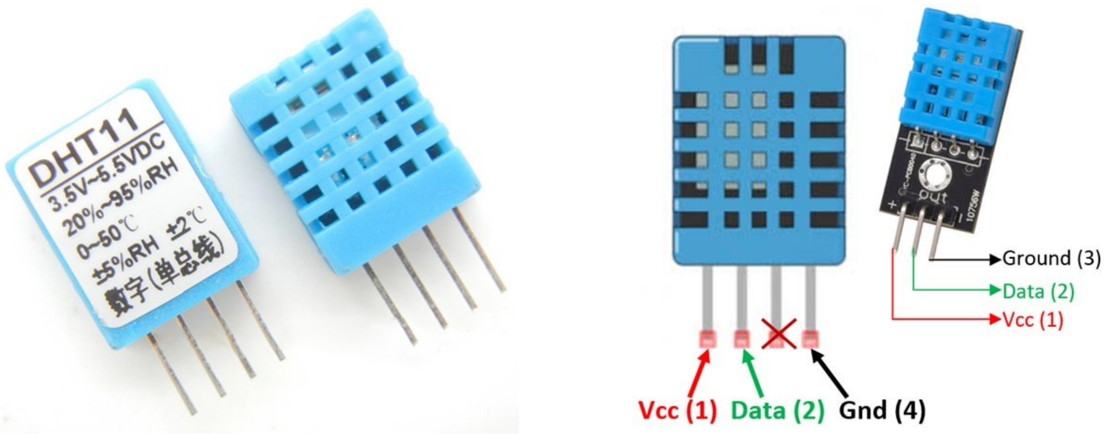
Specifications and Features:

- Optical sensor: IR and red LED combined with a photodetector
- Measures absorbance of pulsing blood
- I2C interface plus INT pin

- 3.3V power supply complete pulse oximeter and heart rate sensor solution, simplifies design, integrated LEDs, photo sensor, and high-performance analog front
- Ultra low power operation increases battery life for wearable devices
- Advanced functionality improves measurement performance, high SNR provides robust motion artifact resilience integrated
- ambient, light cancellation high sample rate capability fast data output capability
- It is an integrated pulse oximetry and heart rate monitor sensor solution.

2.2.3 DHT11 Temperature and Humidity sensor module

The DHT11 sensor is one of the most digital sensors used to measure and determine the level of temperature and humidity and is often used in weather monitoring projects. It generates a digital signal and is compatible with various embedded systems. a high-performance 8-bit microcontroller connected to a resistive element and a wet NTC temperature measuring device.



DHT11 Temperature and Humidity sensor module

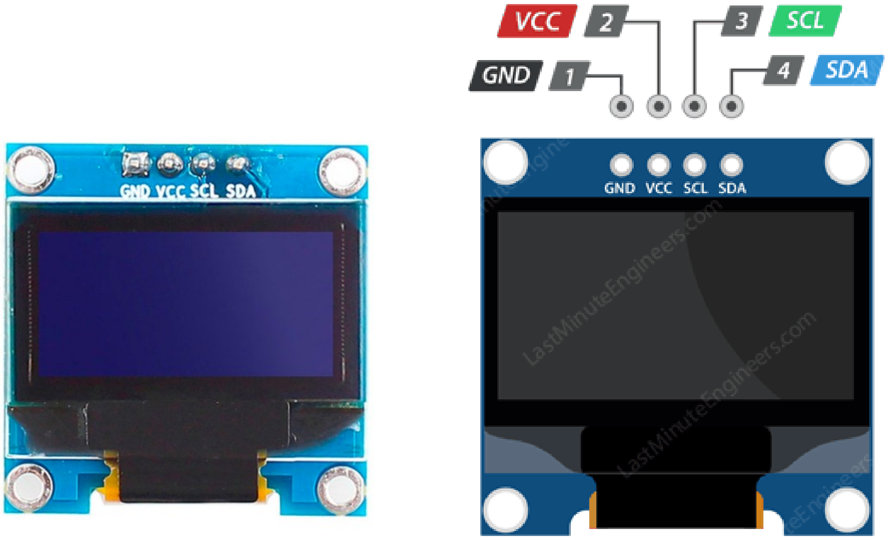
2.2.4 Buzzer:

The buzzer is a sounding device that can convert audio signals into sound signals. It is usually powered by DC voltage. It is widely used in alarms, computers, printers and other electronic products as sound devices.

Buzzer

2.2.5 (0.96-inch) OLED screen display

An OLED (Organic Light-Emitting Diode) display is an integrated graphic display with a resolution of 128 x 64 pixels that allows for the creation of a graphic interface by drawing and displaying text. The TF052 OLED display is based on the SSD1306 circuit and communicates via I2C. It incorporates an SSD1306 with contrast control, display RAM, and an oscillator, reducing the number of external components and power consumption. The general MCU sends data/commands via the selectable 6800/8000 series compatible parallel interface, I2C interface, or serial terminal interface. As a result, it is suitable for a wide range of portable applications. It has four pins: GND, VCC, SCL, and SDA. Figure 19 depicts this. In our proposed system, we used this type of screen.



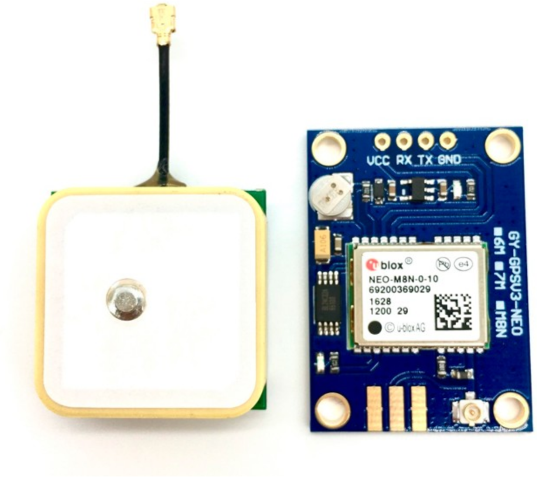
OLED Graphic Display Module.

Specifications:

- Display Technology is OLED (Organic LED)
- MCU Interface is I2C / SPI
- Screen Size is 0.96 Inch Across
- Resolution is 128×64 pixel.
- Operating Voltage from 3.3V to 5V.
- Operating Current is 20mA max.
- Viewing Angle is160°.
- Characters per Row is 21.
- Number of Character Rows 7.

2.2.6 NEO-M8 GPS module

The NEO-M8 GPS module is a high-precision Global Navigation Satellite System (GNSS) receiver module that can receive signals from GPS, GLONASS, Galileo, and BeiDou satellite systems. It is designed to provide accurate positioning, velocity, and time information to various applications, including navigation systems, drones, and autonomous vehicles. The NEO-M8 module features advanced navigation algorithms, low power consumption, and fast acquisition and tracking performance. It also supports various communication interfaces, such as UART, I2C, and USB, for easy integration with different devices. The NEO-M8 GPS module is widely used in many industries, including transportation, agriculture, surveying, and geolocation.



NEO-M8 GPS module.

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- Input voltage: 2.7V to 3.6V (Typical 3.3V)
- Power consumption: 23 mA (continuous tracking)

2.2.7 (3.7 V, 1100 mAh) Li-ion battery

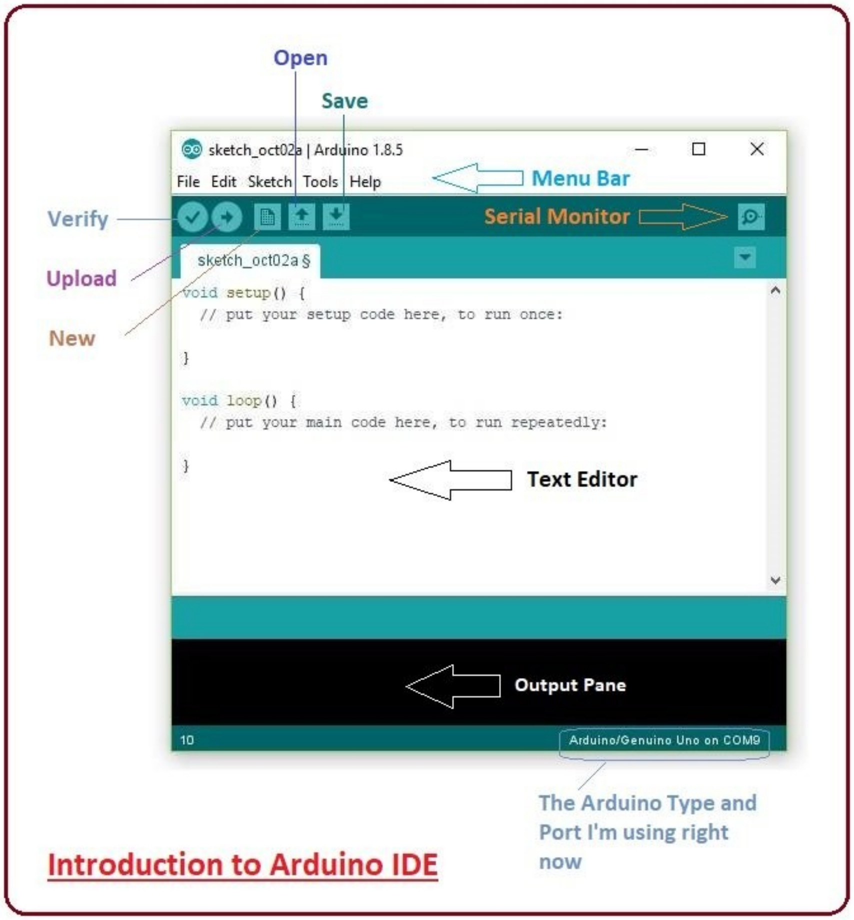
Fig. 3.10 (3.7 V, 1100 mAh) Li-ion battery

2.3 Software:

2.3.1 Arduino IDE

To upload the code to our microcontroller, we use an integrated development environment (IDE) that deals with AVR-type microcontrollers, including Arduino and Esp32, which work in the same environment using the Arduino IDE, which is a software available for various operating systems, Windows, Linux, and Mac. It can be downloaded from the official Arduino website. The code can upload from the Arduino IDE to our microcontroller by connecting the microcontroller to the PC, selecting the port on which the microcontroller is connected, and then uploading the code quickly.

Arduino software URL to download: https://www.arduino.cc/en/software


Open
Save
sketch_oct02a | Arduino 1.8.5
File Edit Sketch Tools Help
Menu Bar
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Serial Monitor
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sketch_oct02a §
New
Text Editor
Output Pane
10
Arduino/Genuino Uno on COM9
The Arduino Type and Port I'm using right now
Introduction to Arduino IDE

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Arduino Software (IDE)

6 References:

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